Europäisches Patentamt

European Patent Office

Office européen des brevets

REC'D 24 NOV 2004

WIPO PCT

Bescheinigung

Certificate

Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

DK/04/740

Patentanmeldung Nr. **Patent application No.** **Demande de brevet n°**

03025509.5

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

BEST AVAILABLE COPY

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

Anmeldung Nr:
Application no.: 03025509.5
Demande no:

Anmeldetag:
Date of filing: 06.11.03
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

BANG & OLUFSEN TECHNOLOGY A/S
Peter Bangs Vej 15
7600 Struer
DANEMARK

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Charge mode control

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

H02M/

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL
PT RO SE SI SK TR LI

The present invention relates to an apparatus and a method for converting power fron a power input to an output power supply, which apparatus comprises a serial reso nance converter containing at least two serial coupled semiconductor switches havin; a common output terminal connected to at least one first coil which coil can be a par of a transformer having a second winding connected to a rectifier means, which recti fier means has its output connected to output terminals, where a first feedback circui is connected from the output terminal to an error amplifier, which error amplifier i: connected to an input at a control circuit, which output is connected over drive means to the input of the semiconductor switches In serial with the primary coil o transformer there is a serial resonant capacitor.

An apparatus as described above is known from the use of an integrated circuit L659{ or similar. This integrated circuit comprises a current controlled oscillator which out put is connected over driver means to two inverse output terminals, which are directl; connectable to the input of semiconductor switches. The oscillator part in L6598 i: also connected to the outside through a connecting terminal where this terminal i: connected to an external capacitor that together with two internal current controlle(current generators set the frequency. An input signal at the integrated circuit is so con nected that changes in current through this terminal lead to control of the frequency. I is achieved that the voltage over the connected capacitor is changing in a linear wa; between two voltage situations. Each time the charge of the capacitor changes its sigı in charge current, the oscillator changes its output from a first to a second value, whicl over the drivers activates and/or deactivates the semiconductor switches. A feedbacl from the power output is used to control the size of the current used to charge or dis charge the capacitor and, thereby, to a change in the frequency of an oscillating systen form by extern components. The oscillating frequency is in normal operation oscillat ing over the resonance frequency, where the feedback signal leads to a frequenc; change to a lower frequency near the resonance frequency if a higher load is needed.

The scope of the invention is to improve and stabilize an output voltage having a fas response to a change in load.

This can be achieved with an apparatus or method if modified so that the appa further comprises a second feedback circuit leading a signal from a serial reso capacitor, which capacitor is connected to the first coil or transformer, to the osci part of the control circuit, which second feedback circuit contains a signal depe on the actual change of the voltage over the serial resonance capacitor.

In this way, it can be achieved that the oscillating frequency is under influence o signal that depends on the voltage at the capacitor connected in serial to the co transformer. The voltage at the capacitor connected to the first coil or transforme pends on the current flowing through the output of the power supply. This means at high load, a very powerful signal will be transmitted directly to the input at th cillator pin in the control circuit. This will change the operation of the circuit i charge mode operation. As the load on the output is reduced, the influence of the ond feedback signal will be reduced, and the influence of the charge mode is red and the operation mode changes back into a frequency mode of operation. At the s up of the power supply, there will be no signal at the second feedback circuit, an whole start-up will take place in frequency mode.

~~The second feedback circuit can be connected from the serial resonance capacitor~~ nected to the coil or transformer through at least one further capacitor where at one further capacitor is connected to an earth connection. In this way, a reductic the voltage of the feedback signal can be achieved. The degree of influence ca adjusted by changing the size of the two capacitors, hereby, it can be achieved tha change of operation mode starts its influence on demand, which is defined from size of the capacitors. The output of the one or two capacitors can be connected t input terminal of the oscillator part of the control circuit through at least one capa and resistor. Hereby, it can be achieved that the signal of the second feedback circ reduced to a value that can be used effectively to influence the charging and disch ~~ing of the capacitor connected to the oscillator part in the control circuit. This ca~~ important in the design of new power supplies in that a very simple change of a c ponent at a printed circuit board leads to a major change in function of the power ply.

Together with L6598 or similar circuits a second feedback circuit is needed. It contains an inverting amplifier, which output can be connected to the input terminal of the oscillator part through at least one capacitor and one resistor. Hereby, it can be achieved that the signal of the second feedback circuit is inverted and amplified to a value that can be used effectively to influence the charging and discharging of the capacitor connected to the oscillator pin on the control circuit.

The output of the inverting amplifier can be connected to a serial connection of a resistor and a further capacitor, which serial connection is coupled in parallel to the capacitor. This can influence the characteristics of the signal that is created as a mix of the output from the inverter and amplifier and from the constant current generators placed inside the integrated circuit. These components generate the automatic change between frequency-mode and charge-mode.

The invention can also be described as a method for power control in serial resonant to the switch mode power converters operating in frequency mode by normal operation where a first feedback signal from the output is converted to an input to switching means, and by increasing load, the mode of operation is changed into a charge mode control by a second feedback signal, which second feedback signal is based on the actual charging current on the serial resonant capacitor.

In this way, it is achieved that the start-up of the power converter takes place as usual in frequency mode, and where light load operation also takes place in this mode. However, if the load increases, an automatic change in the direction of operation in charge mode takes place where a voltage change on the serial resonant capacitor feedback depending on the actual current demand of the output is used as the feedback signal to the control circuit. Full-time operation in charge mode could be critical because power supplies might have problems with starting in charge mode as no feedback signal occurs in the start-up situation and might have problems with stability in light load. This problem is completely solved by letting the start and light load take place in frequency mode, and only use charge mode operation if the output current increases. Under normal operation, a combination of frequency mode and charge mode is possible where direct charge mode operation only takes place at high load.

In the following, the invention is described according to drawings, where

fig. 1 shows a diagram of one possible embodiment from state of the art,

fig. 2 shows a first embodiment of the invention, and

fig. 3 shows a further embodiment of the invention.

Fig. 1 describes a switch mode power supply 2 having a power input terminal 4 marily for DC-power, and output terminals 6, 8 between which the power supply deliver DC-power. Semiconductor switches 10, 12 are connected so that if switch is open, switch 12 is closed. Hereby, the voltage at the connection point 14 betw the two semiconductor switches 10, 12 changes from zero and up to the input D voltage. The point 14 is connected to a first coil 15 from where current is flowing a coil 16, which is part of a transformer 18. The coil 16 is further connected to a pacitor 19. The transformer 18 contains further a coil 20, which is connected to re fier means, which can be formed as a bridge rectifier 20 having an input terminal A rectified DC power is delivered at the output 24 towards the output terminals between which a capacitor C-out and a resistor R-load are shown. A feedback sig 26 is connected to the output terminal 6. The feedback signal 26 is sent to an er amplifier 28. The now converted feedback signal 29 is led forwards to electrical iso tion means 30 which in practice is in the form of an optocoupler. This optocoupler connected to a pin 4 of the integrated circuit L6598. Inside the integrated circuit 4 an internal power supply comprising a voltage reference connected to the pin 4. O side the integrated circuit is the optocoupler connected to the pin 4 through a se resistor. Also connected to the pin 4 a resistor is connected to the earth connection. this way, all currents between two levels can be generated to flow from the pin 4 pending on the collector voltage on the transistor in the optocoupler 30. In this w the feedback signal level defines the current. A current change in the pin 4 leads t change in size of the current in the constant current generators 42, 44. This leads t change of the charging and the de-charging speed of the capacitor 46. Hereby, the cillating frequency is over the switching means 10, 12 and the coil 15. The coil 16 the transformer and the capacitors 19 is changed according to the load. A switchi means 41 defines which of the constant current generators 42, 44 that are to be acti Both cannot be active at the same time. The common output from the two const

current generators 42, 44 is led through a pin 3 at the integrated circuit. Outside the pin 3 a capacitor 46 is connected. Charging a capacitor 46 by a constant current leads to a linear increase or decrease in voltage over the capacitor 46. In this way, a three-angle voltage is generated at the pin 3 of the integrated circuit. This signal with a three-angle voltage is over a line 32 led to the input of two comparators and a flip-flop. The output flip-flop 36 is switching its output depending on the input of the terminal 32 and on a reference voltage. The output of the flip-flop 36 is connected to driving means 38, 40. Output terminals at the integrated circuit are pin 11 and pin 15. Pin 11 has the number 45 and pin 15 the number 43. These are connected to the input of the semiconductor switching means 10, 12.

In fig. 1, an apparatus operating in frequency mode is described. In all situations, there is no option for changing to another mode of operation. In most situations, this way of operation is sufficient, especially as this circuit is able to start automatically without the risk of not starting.

Fig. 2 shows a second embodiment according to the invention. Fig. 2 is using a smith trigger control circuit. From the switching means through the coil 15 to the optocoupler the circuit is similar to fig 1. Instead the concentration is on the changes that are made. From the transformer 18 connected at 51 at the connection between the coil 16 as part of the transformer 18 and the capacitor 19, a capacitor 52 is connected. This capacitor 52 is further connected to a capacitor 54, which is further connected to the earth connection 56. From the main point between the capacitor 52 and 54, a feedback line 50 is connected. This feedback line is now further connected to the capacitor Cr and resistor Rr designated as 46,47 and connected to the negative input of a smith trigger. L6598 is replaced with a smith trigger control circuit 134. The optocoupler 30 is connected to the smith trigger control circuit 134 with two voltage controlled current generators. Depending on the output of the smith trigger, Cr 46 is charged or decharged with the current controlled by the output of the optocoupler. If Cr 46 was connected to the ground without the feedback 50 and Rr 47, we have normal frequency control. The smith trigger output 136 is connected to driving means 138, 140 that is connected to switching means 10, 12. In operation, the three-angle voltage at the capacitor 46 is now receiving influence from the voltage which depends on the current

flowing through the coil 15. The current flowing through the coil 15,16 depends on t current of the transformer 18 and as such also on the current flowing in the coil 2 The current in the coil 20 depends on the size of the load connected to the output t minals 6,8. In this way, the signal picked up at the point 51 depends on the load of t output terminals. This signal is over the line 50 added to the voltage over the capaci 46. In this way, the charging of the Cp 19 is used as a feedback signal, and if Cr was removed and Rr 47 was alone, this power supply would operate in charge mo Charge mode is a critical mode of operation in that the power supply in charge mo and light load the gain change. With Cr 46 connected by a combination where norm frequency mode is used at light load, and by increasing load, a soft change to char mode takes place, and by extreme high load, the charge mode is fully taken over by t control of the power supply.

Fig. 3 partly contains the same circuit as described in fig. 1, but is modified accordi to fig. 2 in that the second feedback circuit is now changed to another way of oper tion. Now, the second feedback circuit 50 contains an inverter and amplifier circuit which is necessary if L6598 have to be used. The output of this inverter and amplifi 60 is connected through a capacitor 62 and a resistor 64 to the pin 3 of L6598, whi is connected to an oscillator part of the control circuit 34. In parallel to the capacit 62, a resistor 64 and a capacitor 66 is connected in serial. Furthermore, from the com mon point of the capacitor 66, the capacitor 62 and the output from the inverter ar amplifier 60 are connected to a capacitor 68 which is connected to the earth conne tion.

In operation, the inverter and amplifier circuit 60 is able to change the shape of tl signal 50 into a signal shape that much better can be added to the signal generated t the capacitor 62 and resistor 64 which are connected to the pin 3 of the integrated ci cuit. An adjustment of the signal is possible by the parallel coupling of the resistor 6 and the capacitor 62, and the further capacitor 68 is connected to the earth connectio in changing the size of the components. The resistor 64 and the capacitor 66 are form ing a high pass filter, which has an impedance close to 64 in the whole operating are of the converter. The capacitor 66 is only a DC separation capacitor. In this way, th impedance of 62,64,66 is close to 64 at low frequency operation and close to 62

high frequency operation. This gives charge mode control at high load and frequenc mode at low load and a soft change between the two modes.

CLAIMS

1. Apparatus (2) for converting power from a power input (4) to an output (6, 8) pow supply, which apparatus (2) comprises a resonance converter containing at least tv serial-coupled-semiconductor-switches-(10,-12)-having-at-least-one-common-outp terminal (14) connected to at least one first coil (15), connected to a coil 16 which part of a transformer (18) having a second coil (20) connected to rectifier means (20 which rectifier means (20) has its output (24) connected to output terminals (6, 8 where a first feedback circuit (26) is connected from the output terminal (6) to an err amplifier (28), which error amplifier (28) is connected to an input (31) at a contr circuit (34,134), which comprises output (36) that is connected over driver means (3 40) to the input (43, 45) of the semiconductor switches (10, 12), **c h a r a c t e r i s e** in that the apparatus further comprises a second feedback circuit (50) leading a sign from a capacitor Cp (19) connected in serial to the first coil (15) to a reference inpu terminal (32,132) at the input of the control circuit (34,134), which second feedbac circuit (50) contains a signal depending on the actual change of the voltage over th serial resonance capacitor Cp (19).

2. Apparatus according to claim 1, **c h a r a c t e r i s e d** in that the second feedbac circuit (50) is connected from the serial resonance capacitor Cp (19) to at least on capacitor (52) where at least one further capacitor (54) is connected to a commo ground (56).

3. Apparatus according to claim 1 or 2, **c h a r a c t e r i s e d** in that the second feed back circuit (50) contains an inverting amplifier (60), which output is connected to th input terminal (32) through at least one capacitor (62).

4. Apparatus according to claim 3, **c h a r a c t e r i s e d** in that the output from th inverting amplifier (60) is connected to a serial connection of a resistor (64) and a fu ther capacitor (66), which serial connection I is coupled in parallel to the capacito (62).

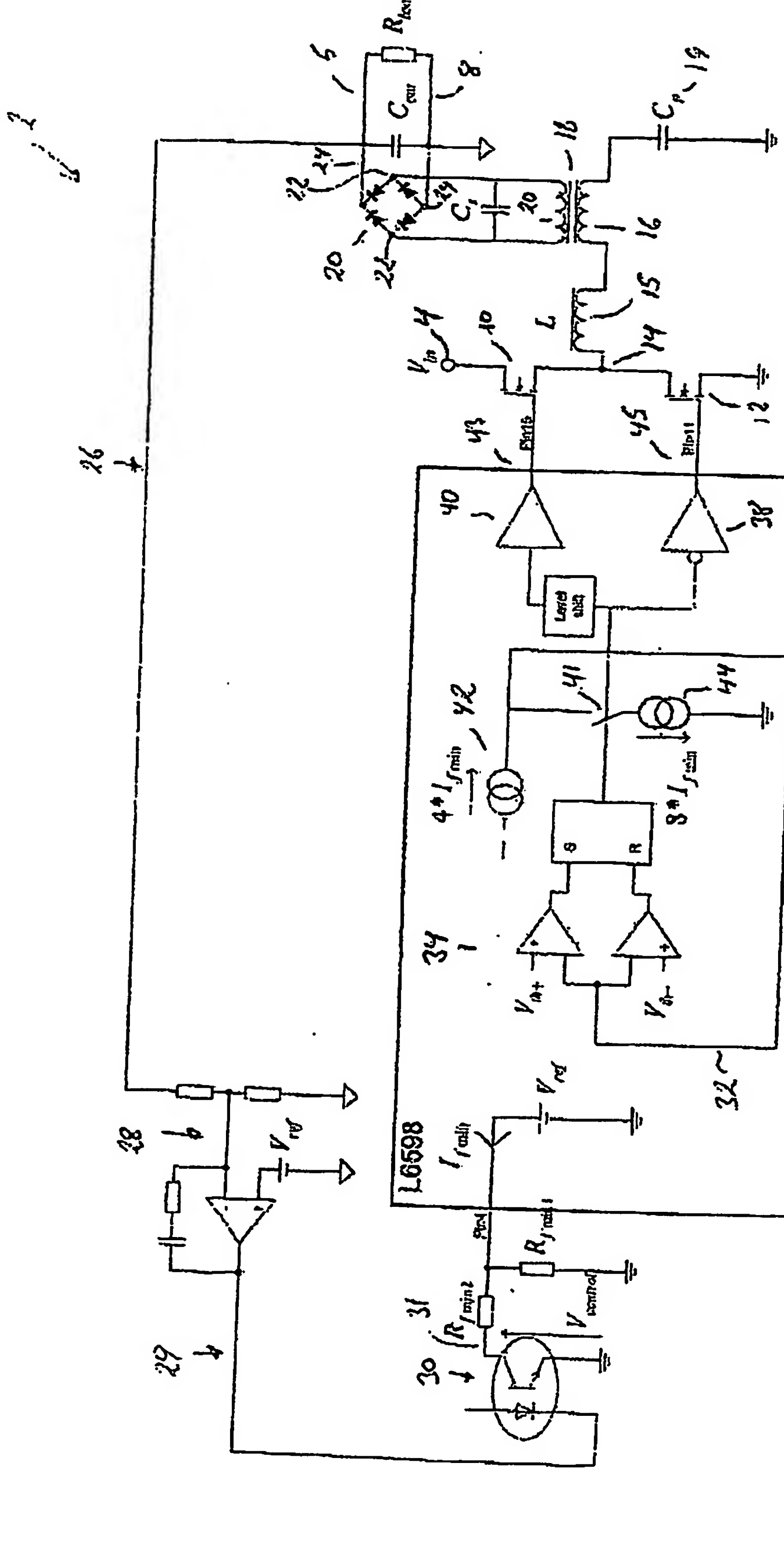
5. Method for power conversion control in serial resonance switch mode power converters operating in frequency mode at normal operation where a first feedback signal from the output is converted to an input to switching means **characterised** in that by increasing load, the mode of operation is changed into a charge mode control by a second feedback signal, which second feedback signal is based on the actual charging current on the serial resonant capacitor.

ABSTRACT

The present invention relates to an apparatus and a method for converting power fro a power input to an output power supply, where a first feedback circuit is connecte from the output terminal to an error amplifier, which error amplifier is connected ove electric isolation means to an input at a control circuit, which output is connected ove driver means to the input of the semiconductor switches. The scope of the invention to reach a high effective and fast responding switch mode power supply in changin the mode of operation depending on the actual demand. This can be achieved with a apparatus or method if modified so that the apparatus further comprises a second feed back circuit leading a signal from a serial resonance capacitor to a reference input te minal at the control circuit, which second feedback circuit contains a signal dependin on the actual current in the coil. This way, it can be achieved that the signal at the sec ond feedback input at the control circuit now partly is under influence of the signa that depends on the current flowing through the coil of the transformer. The curren flowing through the first coil of the transformer is depending on the current flowin through the output of the power supply. This means that at high load, a very powerfu signal will be transmitted through the second feedback at the control circuit that wil change the operation of the circuit into a charge mode operation. As the load on th output is reduced, the influence of the second feedback signal will be reduced, and th influence from the charge mode is reduced and the operation mode is changing bac into a frequency mode of operation.

(Fig. 2)

Fig 1



L6598
Level shift
R_load
C_out
C_1
C_P
C_f
V_in
L
V_ref
V_th+
V_th-
R_fmin
R_fmin2
V_control
I_fmin
4*I_fmin
8*I_fmin
S
R

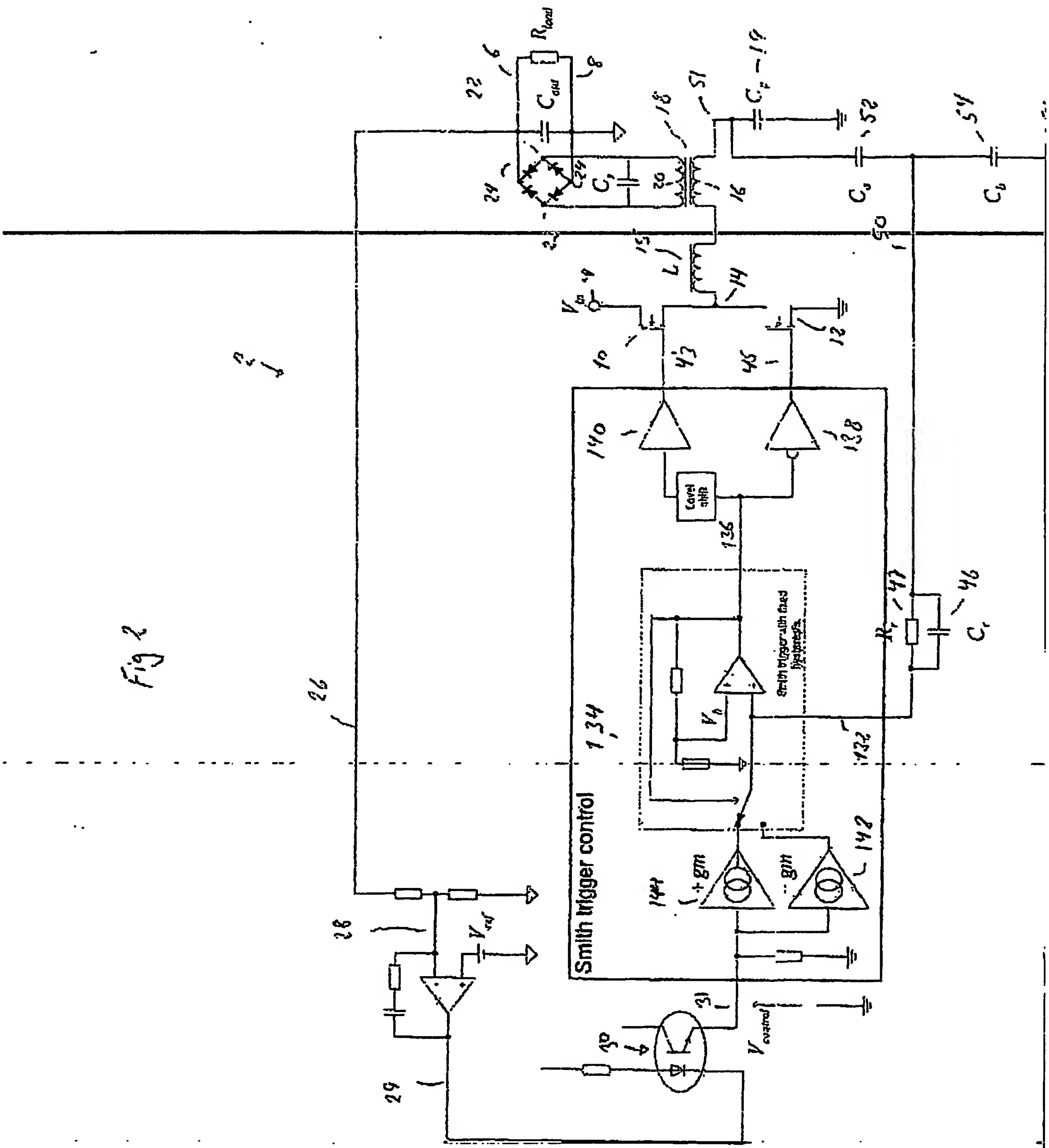
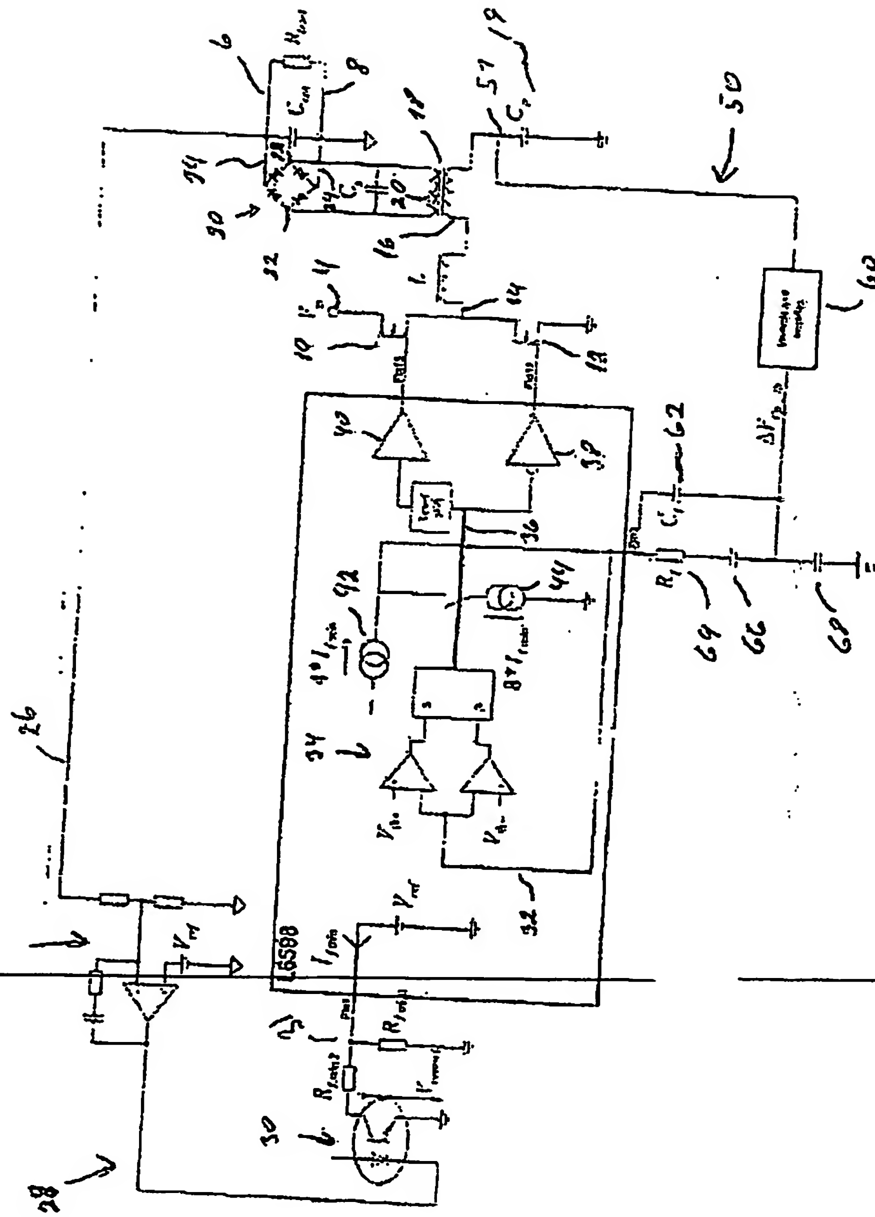

Smith trigger control
Smith trigger with fixed hysteresis
Level shift
R_{load}
C_{out}
V_{in}
V_{ref}
$V_{control}$
+gm
-gm

Fig 2

Fig. 3



This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☑ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☑ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.